

```
In[9]:= SIZE = 900
```

```
Out[9]= 900
```

```
In[10]:= SIDE = 6
```

```
Out[10]=
```

```
6
```

```
In[11]:= dice = RandomInteger[{1, SIDE}, SIZE]
```

```
Out[11]=
```

```
{1, 2, 4, 4, 5, 2, 2, 6, 4, 5, 1, 4, 2, 5, 3, 5, 1, 5, 6, 3, 2, 2, 4, 6, 1, 4, 3, 2, 4, 4, 4, 3,
 5, 1, 5, 2, 2, 4, 4, 1, 3, 3, 3, 2, 5, 2, 2, 6, 2, 2, 6, 5, 3, 4, 6, 6, 6, 3, 2, 4, 2, 4,
 4, 2, 6, 6, 2, 1, 3, 2, 1, 4, 6, 6, 4, 3, 5, 4, 3, 4, 5, 1, 5, 6, 2, 6, 5, 6, 1, 3, 5, 3,
 2, 4, 1, 4, 3, 4, 1, 2, 1, 3, 2, 5, 1, 3, 4, 6, 5, 4, 4, 4, 1, 4, 6, 1, 3, 5, 2, 2, 6, 6,
 5, 2, 4, 3, 4, 3, 1, 6, 4, 6, 3, 6, 3, 4, 1, 4, 3, 6, 2, 1, 3, 1, 3, 2, 1, 4, 2, 1, 3, 4,
 3, 3, 6, 6, 3, 1, 3, 2, 5, 2, 2, 2, 5, 4, 5, 3, 6, 4, 5, 1, 1, 6, 2, 1, 1, 5, 5, 3, 2, 2,
 5, 4, 5, 1, 2, 1, 4, 6, 6, 5, 2, 6, 3, 3, 4, 3, 5, 4, 4, 4, 2, 1, 5, 1, 2, 1, 5, 5, 6, 2,
 2, 3, 5, 2, 1, 3, 2, 2, 3, 4, 6, 1, 3, 6, 1, 1, 6, 4, 1, 5, 3, 1, 3, 6, 2, 1, 1, 1, 2, 5,
 2, 4, 2, 1, 1, 4, 2, 5, 1, 4, 1, 4, 6, 6, 2, 4, 2, 6, 6, 6, 3, 4, 4, 6, 4, 3, 4, 3, 5, 6,
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 5, 2, 6, 3, 2, 5, 6, 2, 4, 4, 6, 6, 4, 6, 5, 2, 6, 6, 2, 4, 4, 2, 2, 4, 6, 4, 4, 6, 6, 2,
 4, 2, 1, 2, 6, 2, 2, 1, 1, 1, 4, 6, 6, 1, 4, 3, 3, 2, 4, 5, 3, 2, 3, 5, 6, 1, 6, 3, 3, 4,
 2, 3, 6, 2, 4, 3, 1, 3, 5, 4, 5, 1, 3, 5, 6, 1, 3, 2, 2, 6, 2, 4, 6, 2, 2, 4, 4, 6, 2, 3,
 2, 6, 3, 2, 4, 3, 5, 1, 4, 2, 2, 2, 6, 6, 6, 5, 4, 1, 6, 4, 5, 4, 4, 6, 4, 5, 4, 4, 1, 4,
 5, 6, 1, 1, 4, 1, 6, 6, 6, 2, 5, 1, 3, 3, 5, 2, 4, 5, 4, 5, 5, 1, 3, 5, 1, 6, 4, 1, 6, 1,
 3, 1, 6, 6, 4, 3, 5, 3, 3, 2, 3, 5, 6, 6, 1, 5, 1, 2, 1, 2, 2, 5, 6, 1, 1, 6, 5, 2, 2, 6,
 2, 2, 3, 3, 3, 3, 5, 4, 5, 4, 5, 6, 3, 5, 2, 1, 2, 4, 2, 4, 6, 4, 6, 6, 1, 5, 4, 6, 1, 1,
 4, 2, 5, 2, 3, 2, 1, 3, 6, 3, 1, 3, 3, 1, 1, 4, 1, 2, 4, 2, 3, 3, 6, 5, 3, 5, 1, 6, 6, 4,
 3, 6, 6, 5, 3, 3, 3, 6, 1, 1, 3, 6, 6, 2, 5, 5, 6, 2, 1, 4, 2, 2, 4, 4, 2, 3, 2, 3, 6, 6,
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 5, 6, 2, 6, 3, 3, 3, 2, 5, 5, 3, 1, 6, 4, 4, 2, 4, 4, 3, 6, 6, 6, 2, 3, 1, 1, 1, 3, 3, 6,
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 3, 6, 3, 4, 3, 6, 3, 2, 6, 4, 1, 5, 1, 2, 5, 3, 6, 5, 2, 5, 3, 2, 6, 1, 1, 5, 5, 5, 6, 6,
 2, 1, 2, 4, 2, 4, 3, 6, 3, 4, 1, 5, 6, 5, 2, 6, 3, 1, 1, 5, 2, 5, 5, 2, 2, 4, 6, 3, 5, 4,
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 6, 5, 5, 5, 3, 6, 5, 3, 2, 3, 3, 6, 4, 3, 1, 4, 6, 4, 3, 6, 1, 2, 6, 3, 4, 6, 2, 4, 4,
 4, 5, 6, 3, 3, 3, 3, 4, 2, 2, 3, 6, 4, 1, 4, 4, 4, 3, 4, 2, 4, 6, 4, 1, 5, 2, 2, 3, 5,
 1, 1, 3, 5, 1, 4, 1, 6, 5, 2, 3, 1, 6, 1, 2, 5, 3, 5, 6, 6, 5, 4, 4, 6, 1, 2, 3, 5, 3, 5}
```

```
In[12]:= ideal = Table[Mod[i, SIDE] + 1, {i, 0, SIZE - 1}]
```

Out[12]=

[illegible]

```
In[13]:= freqs = BinCounts[dice, {1, SIDE + 1, 1}]
```

Out[13]=

$$\{136, 158, 157, 163, 128, 158\}$$

```
ln[14]:= idealFreqs = ConstantArray[SIZE / SIDE, SIDE]
```

Out[14]=

$$\{150, 150, 150, 150, 150, 150\}$$

<https://mathematica.stackexchange.com/questions/5579/performing-a-chi-square-goodness-of-fit-test>

```
In[21]:= PearsonChiSquareTest[dice, ideal, "DegreesOfFreedom"]
```

```
Out[21]=
```

```
4
```

```
In[25]:= PearsonChiSquareTest[dice, ideal, "TestDataTable"]
```

```
Out[25]=
```

	Statistic	P-Value
Pearson χ^2	3.29086	0.510382

<https://www.graphpad.com/quickcalcs/chisquared1.Chi-square/>

```
In[17]:= myChi2 = N[Total[(freqs - idealFreqs)^2 / idealFreqs]]
```

```
Out[17]=
```

```
6.84
```

```
In[18]:= (freqs - idealFreqs)^2 / idealFreqs
```

```
Out[18]=
```

$$\left\{ \frac{98}{75}, \frac{32}{75}, \frac{49}{150}, \frac{169}{150}, \frac{242}{75}, \frac{32}{75} \right\}$$

```
In[19]:= CDF[ChiSquareDistribution[SIDE - 1], myChi2]
```

```
Out[19]=
```

```
0.767186
```

```
In[20]:= 1 - CDF[ChiSquareDistribution[SIDE - 1], myChi2]
```

```
Out[20]=
```

```
0.232814
```

```
In[27]:= Count[RandomInteger[{1, SIDE}, SIZE], 1]
```

```
Out[27]=
```

```
149
```

```
In[29]:= myFreq1 = {}; For[i = 1, i ≤ 1000, i++,
```

```
AppendTo[myFreq1, Count[RandomInteger[{1, SIDE}, SIZE], 1]
```

```
];
```

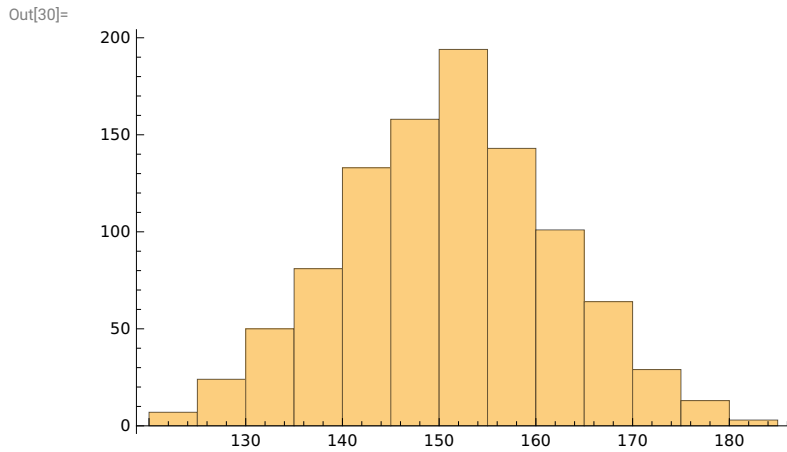
```
Print[myFreq1];
```

```
{160, 183, 149, 147, 129, 128, 141, 151, 159, 160, 133, 154, 148, 147, 156, 139, 147, 143,
 131, 167, 164, 169, 144, 176, 125, 162, 133, 175, 157, 157, 150, 135, 134, 161, 155,
 139, 144, 147, 138, 137, 148, 144, 151, 148, 154, 150, 154, 151, 154, 140, 134, 155,
 146, 148, 131, 166, 148, 143, 142, 144, 159, 142, 158, 164, 151, 154, 151, 152, 166,
 152, 149, 146, 157, 156, 148, 142, 152, 153, 140, 145, 171, 151, 151, 157, 152, 150,
 154, 166, 138, 132, 157, 162, 165, 177, 140, 160, 160, 145, 145, 127, 161, 155, 158,
 150, 170, 141, 155, 126, 135, 155, 152, 143, 131, 159, 168, 169, 161, 148, 152, 162,
 154, 152, 162, 133, 148, 149, 140, 147, 149, 136, 143, 157, 157, 149, 147, 153, 142,
 171, 157, 158, 160, 160, 161, 139, 166, 130, 140, 146, 136, 141, 151, 139, 153, 157,
 131, 164, 162, 161, 160, 164, 174, 147, 161, 166, 161, 170, 149, 138, 176, 136, 163,
 150, 157, 146, 140, 151, 150, 157, 157, 125, 152, 153, 162, 158, 162, 131, 148, 151,
```

145, 154, 151, 156, 168, 164, 169, 146, 161, 170, 166, 178, 131, 138, 148, 166, 169, 160, 172, 142, 150, 134, 152, 136, 136, 155, 166, 153, 150, 162, 159, 134, 144, 152, 144, 161, 137, 137, 156, 143, 154, 147, 159, 138, 171, 134, 136, 167, 159, 157, 140, 150, 151, 141, 151, 142, 139, 172, 164, 160, 157, 149, 146, 130, 149, 145, 149, 166, 127, 154, 148, 150, 135, 159, 167, 148, 169, 137, 156, 146, 143, 150, 155, 127, 134, 142, 150, 146, 164, 153, 151, 137, 153, 147, 143, 146, 166, 150, 157, 158, 169, 146, 134, 135, 153, 150, 147, 166, 151, 161, 140, 136, 144, 129, 151, 160, 146, 144, 143, 161, 144, 135, 160, 155, 146, 158, 145, 151, 128, 130, 137, 172, 152, 167, 141, 147, 144, 157, 154, 159, 155, 147, 152, 138, 150, 164, 163, 145, 148, 149, 145, 153, 130, 156, 163, 153, 162, 153, 145, 147, 141, 149, 136, 156, 149, 153, 137, 154, 154, 135, 126, 142, 144, 144, 135, 166, 157, 144, 154, 139, 142, 152, 162, 142, 142, 149, 121, 135, 156, 146, 171, 143, 148, 137, 149, 155, 163, 142, 151, 153, 158, 170, 162, 157, 144, 150, 152, 154, 157, 145, 151, 131, 169, 146, 169, 156, 147, 151, 147, 141, 157, 158, 149, 145, 157, 159, 165, 159, 143, 142, 143, 141, 152, 138, 154, 153, 159, 146, 154, 150, 154, 135, 126, 152, 141, 133, 135, 160, 148, 148, 171, 144, 154, 151, 156, 129, 145, 154, 163, 164, 162, 148, 158, 144, 151, 154, 141, 155, 156, 146, 172, 146, 160, 147, 171, 148, 160, 127, 144, 168, 161, 162, 170, 135, 152, 152, 164, 145, 153, 145, 154, 154, 156, 177, 124, 152, 156, 126, 152, 166, 156, 148, 150, 147, 148, 140, 179, 161, 159, 131, 144, 160, 129, 153, 156, 154, 166, 142, 163, 151, 150, 157, 143, 153, 153, 143, 133, 145, 154, 137, 147, 145, 147, 149, 132, 146, 146, 154, 139, 146, 156, 135, 134, 155, 131, 143, 138, 168, 143, 145, 150, 140, 151, 152, 137, 154, 179, 153, 153, 149, 156, 148, 152, 157, 152, 149, 129, 127, 145, 122, 168, 146, 153, 143, 154, 139, 142, 167, 143, 165, 144, 164, 149, 163, 149, 163, 161, 175, 165, 158, 156, 170, 133, 157, 154, 146, 166, 142, 134, 130, 128, 156, 165, 148, 143, 168, 140, 148, 154, 152, 144, 152, 140, 142, 144, 139, 158, 154, 140, 159, 152, 152, 150, 170, 138, 155, 160, 139, 135, 143, 152, 162, 135, 142, 158, 145, 159, 145, 170, 146, 152, 147, 157, 153, 161, 135, 155, 155, 159, 157, 153, 162, 142, 141, 142, 155, 165, 157, 170, 154, 150, 172, 158, 137, 143, 152, 133, 136, 162, 150, 130, 151, 132, 158, 141, 148, 165, 161, 164, 147, 143, 137, 159, 153, 138, 156, 150, 135, 139, 142, 129, 130, 148, 146, 165, 146, 149, 133, 165, 140, 154, 154, 136, 170, 149, 149, 141, 176, 159, 157, 147, 171, 159, 159, 143, 163, 151, 152, 155, 142, 157, 153, 133, 137, 157, 144, 143, 156, 169, 138, 143, 165, 142, 153, 152, 168, 169, 143, 154, 137, 152, 158, 153, 160, 157, 164, 129, 156, 141, 142, 153, 147, 159, 159, 151, 147, 137, 152, 136, 150, 168, 179, 154, 168, 166, 151, 148, 136, 141, 163, 147, 122, 139, 157, 138, 143, 139, 161, 153, 156, 180, 142, 160, 166, 166, 145, 142, 153, 154, 157, 145, 155, 147, 161, 141, 145, 155, 162, 133, 148, 162, 133, 169, 142, 135, 145, 142, 156, 151, 169, 160, 159, 153, 133, 150, 161, 145, 147, 159, 156, 158, 170, 147, 148, 144, 151, 155, 153, 157, 166, 146, 147, 135, 165, 162, 171, 148, 138, 144, 122, 151, 142, 128, 158, 139, 148, 154, 152, 170, 135, 162, 134, 173, 169, 152, 145, 174, 153, 149, 162, 138, 153, 155, 134, 144, 153, 155, 155, 163, 153, 148, 160, 146, 149, 143, 151, 166, 180, 150, 140, 157, 151, 155, 144, 155, 143, 149, 158, 162, 139, 166, 150, 158, 157, 134, 144, 150, 165, 156, 150, 162, 124, 152, 161, 142, 152, 149, 159, 162, 149, 157, 164, 151, 131, 133, 156, 147, 154, 151, 142, 145, 129, 146, 161, 152, 157, 140, 151, 150, 144, 141, 154, 175, 153, 143, 146, 145, 124, 136, 148, 146, 144, 145, 158, 163, 154, 152, 161, 135, 147, 178, 131, 155, 150, 157, 151, 163, 167, 159, 147, 134, 148, 153,

```
131, 140, 155, 148, 143, 151, 173, 139, 137, 144, 163, 145, 150, 155, 135, 148,
146, 166, 132, 154, 161, 141, 131, 160, 160, 165, 165, 144, 156, 163, 162, 141,
158, 149, 137, 162, 157, 159, 153, 150, 161, 144, 140, 144, 153, 140, 144, 146, 126}
```

```
In[30]:= Histogram[myFreq1]
```

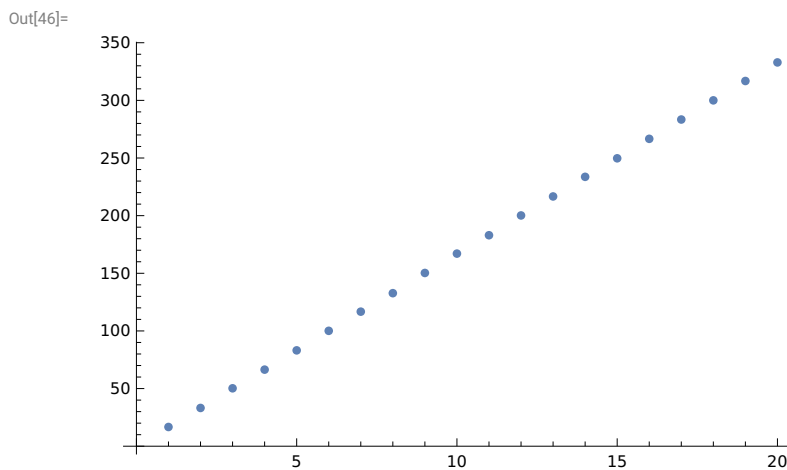


```
In[49]:= SIDE = 6
```

Out[49]=
6

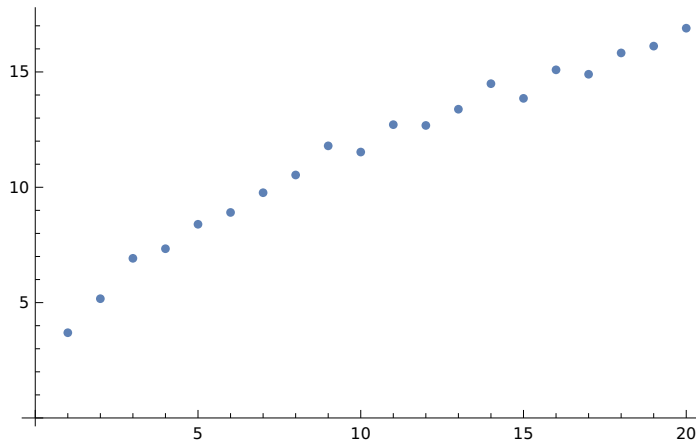
```
myAve = {}; mySTDEV = {}; For[j = 1, j ≤ 20, j++,
myFreq1 = {}; For[i = 1, i ≤ 1000, i++,
AppendTo[myFreq1, Count[RandomInteger[{1, SIDE}, 100 * j], 1]
];
AppendTo[myAve, Mean[myFreq1]];
AppendTo[mySTDEV, StandardDeviation[myFreq1]
];
```

```
In[46]:= ListPlot[myAve]
```



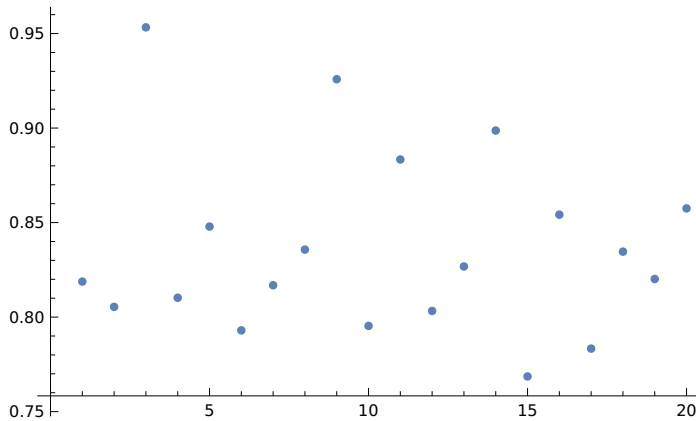
```
In[47]:= ListPlot[mySTDEV]
```

```
Out[47]=
```



```
In[51]:= ListPlot[mySTDEV ^ 2 / myAve]
```

```
Out[51]=
```



```
In[60]:= pvs = {}; For[j = 1, j ≤ 1000, j++,
  freqs = BinCounts[RandomInteger[{1, SIDE}, SIZE], {1, SIDE + 1, 1}];
  idealFreqs = ConstantArray[SIZE / SIDE, SIDE];
  myChi2 = N[Total[(freqs - idealFreqs)^2 / idealFreqs]];
  pv = 1 - CDF[ChiSquareDistribution[SIDE - 1], myChi2];
  AppendTo[pvs, pv];
]; Print[pvs]
```

```
{0.586435, 0.491562, 0.36309, 0.236996, 0.930057, 0.466616, 0.580521, 0.177224,
 0.302346, 0.41751, 0.551337, 0.41588, 0.0347878, 0.793458, 0.608313, 0.598332,
 0.461373, 0.491562, 0.732835, 0.269219, 0.188182, 0.0584045, 0.771467, 0.751212,
 0.445867, 0.0839864, 0.793458, 0.429036, 0.367543, 0.913838, 0.893072, 0.425721,
 0.918391, 0.76339, 0.210912, 0.495189, 0.254354, 0.930057, 0.820836, 0.206186,
 0.909191, 0.902857, 0.881256, 0.658949, 0.793458, 0.650781, 0.229719, 0.52474,
 0.876068, 0.509846, 0.464864, 0.63654, 0.0503327, 0.677386, 0.624397, 0.562931,
 0.508001, 0.286011, 0.610316, 0.283561, 0.457898, 0.702042, 0.679438, 0.708208,
```

0.675334, 0.807246, 0.863699, 0.4307, 0.608313, 0.981853, 0.761365, 0.232814,
0.71848, 0.726687, 0.388849, 0.881256, 0.961483, 0.588411, 0.029857, 0.689708,
0.262272, 0.622379, 0.994954, 0.824678, 0.922849, 0.974412, 0.693819, 0.207124,
0.63654, 0.17316, 0.288477, 0.644669, 0.113395, 0.45444, 0.264571, 0.761365,
0.130435, 0.484356, 0.427377, 0.961483, 0.268051, 0.00640181, 0.704097, 0.787496,
0.826592, 0.743058, 0.981089, 0.262272, 0.425721, 0.753246, 0.439084, 0.738972,
0.387298, 0.936976, 0.57072, 0.634512, 0.20901, 0.616338, 0.8601, 0.259989,
0.930057, 0.644669, 0.785503, 0.622379, 0.169968, 0.121352, 0.385752, 0.930057,
0.654862, 0.94989, 0.320753, 0.614329, 0.0882677, 0.376568, 0.206186, 0.0955382,
0.355758, 0.667134, 0.543671, 0.327534, 0.584461, 0.057223, 0.487951, 0.545583,
0.348536, 0.235945, 0.119606, 0.331655, 0.712318, 0.0400678, 0.333037, 0.0321477,
0.331655, 0.777499, 0.328903, 0.475436, 0.553262, 0.0791026, 0.254354, 0.604314,
0.376568, 0.367543, 0.427377, 0.805287, 0.642634, 0.146938, 0.602318, 0.847297,
0.610316, 0.893072, 0.789487, 0.907622, 0.741016, 0.722585, 0.652821, 0.121352,
0.924313, 0.963634, 0.624397, 0.805287, 0.130435, 0.818908, 0.0411257, 0.624397,
0.677386, 0.81115, 0.367543, 0.699986, 0.449283, 0.0936707, 0.927208, 0.204321,
0.318071, 0.1607, 0.728737, 0.783506, 0.881256, 0.874324, 0.738972, 0.219651,
0.898006, 0.489755, 0.425721, 0.974412, 0.475436, 0.669183, 0.219651, 0.357215,
0.551337, 0.0426512, 0.522866, 0.030819, 0.536058, 0.281129, 0.272748, 0.828501,
0.598332, 0.845443, 0.658949, 0.57072, 0.679438, 0.795439, 0.084827, 0.584461,
0.0535364, 0.566819, 0.834198, 0.468372, 0.299786, 0.710263, 0.693819, 0.279919,
0.99843, 0.42407, 0.940983, 0.0100812, 0.463117, 0.759338, 0.495189, 0.789487,
0.58249, 0.511695, 0.562931, 0.606312, 0.05138, 0.0744832, 0.799389, 0.412634,
0.140793, 0.765413, 0.112845, 0.157711, 0.708208, 0.0422099, 0.574632, 0.205252,
0.691764, 0.275122, 0.265727, 0.029857, 0.185602, 0.491562, 0.118454, 0.515404,
0.212827, 0.41751, 0.606312, 0.38421, 0.606312, 0.726687, 0.791474, 0.354305,
0.600324, 0.0246608, 0.439084, 0.200635, 0.511695, 0.89637, 0.876068, 0.432368,
0.399826, 0.11121, 0.909191, 0.224637, 0.969737, 0.904455, 0.685599, 0.850987,
0.372035, 0.879535, 0.634512, 0.0328324, 0.562931, 0.730786, 0.361615, 0.658949,
0.767433, 0.699986, 0.0500741, 0.370533, 0.29096, 0.0508538, 0.134236, 0.249919,
0.360144, 0.36309, 0.741016, 0.238051, 0.298512, 0.584461, 0.560991, 0.0633632,
0.940983, 0.395095, 0.331655, 0.69793, 0.704097, 0.497008, 0.0918367, 0.549416,
0.207124, 0.592372, 0.161455, 0.995689, 0.498831, 0.382673, 0.233854, 0.348536,
0.736928, 0.907622, 0.225646, 0.681491, 0.037437, 0.537956, 0.412634, 0.832304,
0.103355, 0.63046, 0.375052, 0.845443, 0.747138, 0.414255, 0.839846, 0.953512,
0.667134, 0.928638, 0.951111, 0.0277226, 0.0197984, 0.706153, 0.0122155, 0.799389,
0.238051, 0.568768, 0.0554928, 0.807246, 0.361615, 0.141464, 0.695874, 0.116745,
0.987385, 0.671233, 0.422424, 0.560991, 0.271567, 0.918391, 0.566819, 0.000888778,
0.0179681, 0.437398, 0.779504, 0.930057, 0.498831, 0.924313, 0.249919, 0.836086,
0.0704703, 0.120185, 0.482564, 0.553262, 0.928638, 0.17316, 0.0543668, 0.957011,
0.449283, 0.526618, 0.238051, 0.452717, 0.650781, 0.264571, 0.0701156, 0.439084,
0.404596, 0.537956, 0.598332, 0.559054, 0.38421, 0.839846, 0.515404, 0.442467,
0.936976, 0.865488, 0.487951, 0.157711, 0.183053, 0.212827, 0.981089, 0.543671,
0.769451, 0.144864, 0.136174, 0.75731, 0.902857, 0.765413, 0.240173, 0.497008,
0.00703701, 0.879535, 0.98675, 0.218665, 0.726687, 0.00727553, 0.22064, 0.117882,

0.604314, 0.393527, 0.82276, 0.0759944, 0.539858, 0.29096, 0.0505926, 0.726687,
0.660994, 0.256596, 0.886371, 0.0347878, 0.144178, 0.153321, 0.828501, 0.403002,
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ln[65]:= Ceiling[0.05 - pvs]

[illegible]

Total[Ceiling[0.05 - pvs]]

59

$$N[\text{Total}[\text{Ceiling}[0.05 - pvs]] / 1000]$$

0.059